National Institute for Occupational Safety and Health

Laser Safety in Underground Coal Mines

New laser technologies are being developed for a variety of applications. In the coal mining industry, lasers can be used to detect the presence of dangerous gases, to monitor the level of coal in storage facilities, and to survey the underground mine, to name a few applications.

One of the greatest hazards in underground mines is the ignition of methane gas or coal dust. This leads to the question - just how powerful does a laser beam need to be before it can cause an explosion? NIOSH researchers took an experimental approach to answer this question. The results of their work was cited in justifying the European Committee for Electrotechnical Standardization (CENELEC) (http://www.cenelec.org/Cenelec/Homepage.htm) limits of 150 mW or 20 mW/mm2 for open beam lasers used in coal mines where methane gas may be present. Lasers operating above these levels are considered a potential ignition source.

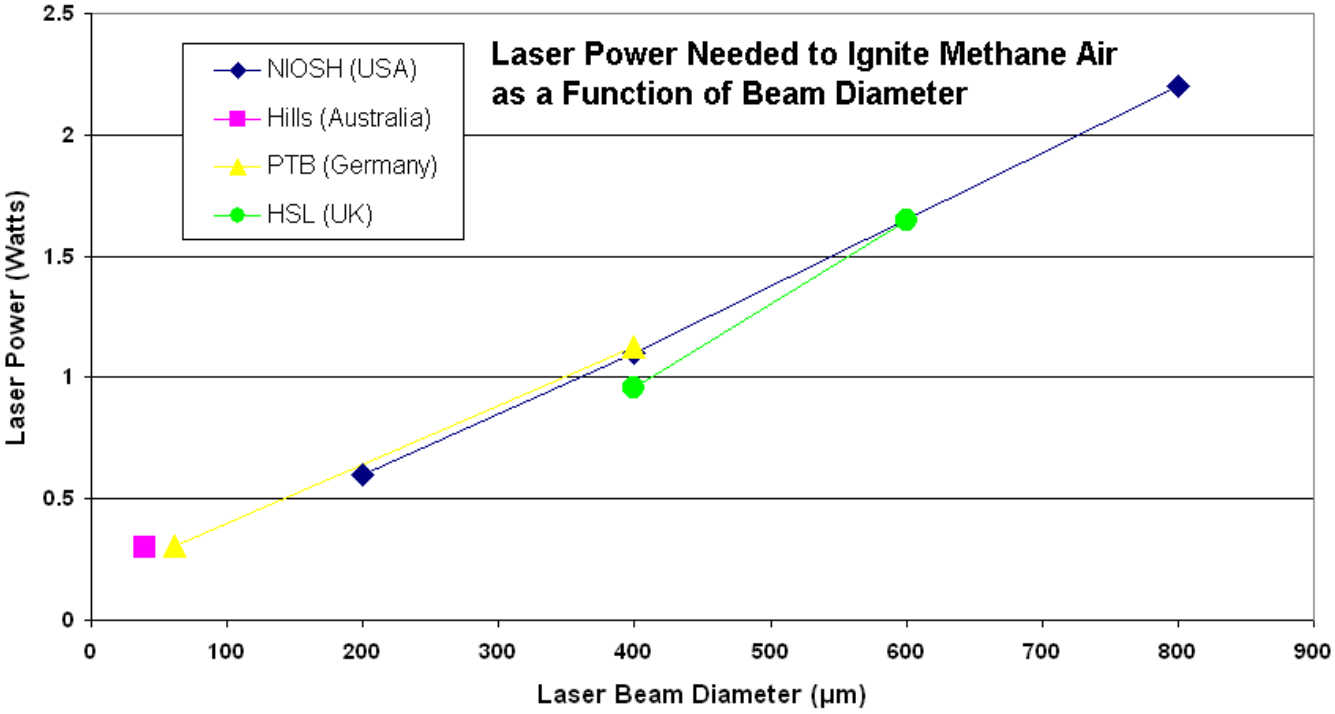
How the NIOSH research was done

Researchers ran several hundred ignition experiments with a powerful laser, studying several variables that can contribute to an explosion. Ignition tests were conducted in a 20 liter chamber that contained the explosions (photo to the right). Explosive concentrations of methane gas or coal dust clouds were put into the chamber. The laser beam was then directed into the chamber using fiber optic cables. If the test resulted in an explosion, the laser power was reduced and the experiment was repeated. The series of tests continued until the laser beam was not powerful enough to ignite the methane or coal dust. Many such series were repeated to study the effect of gas concentration, beam size, and other variables on ignitability.

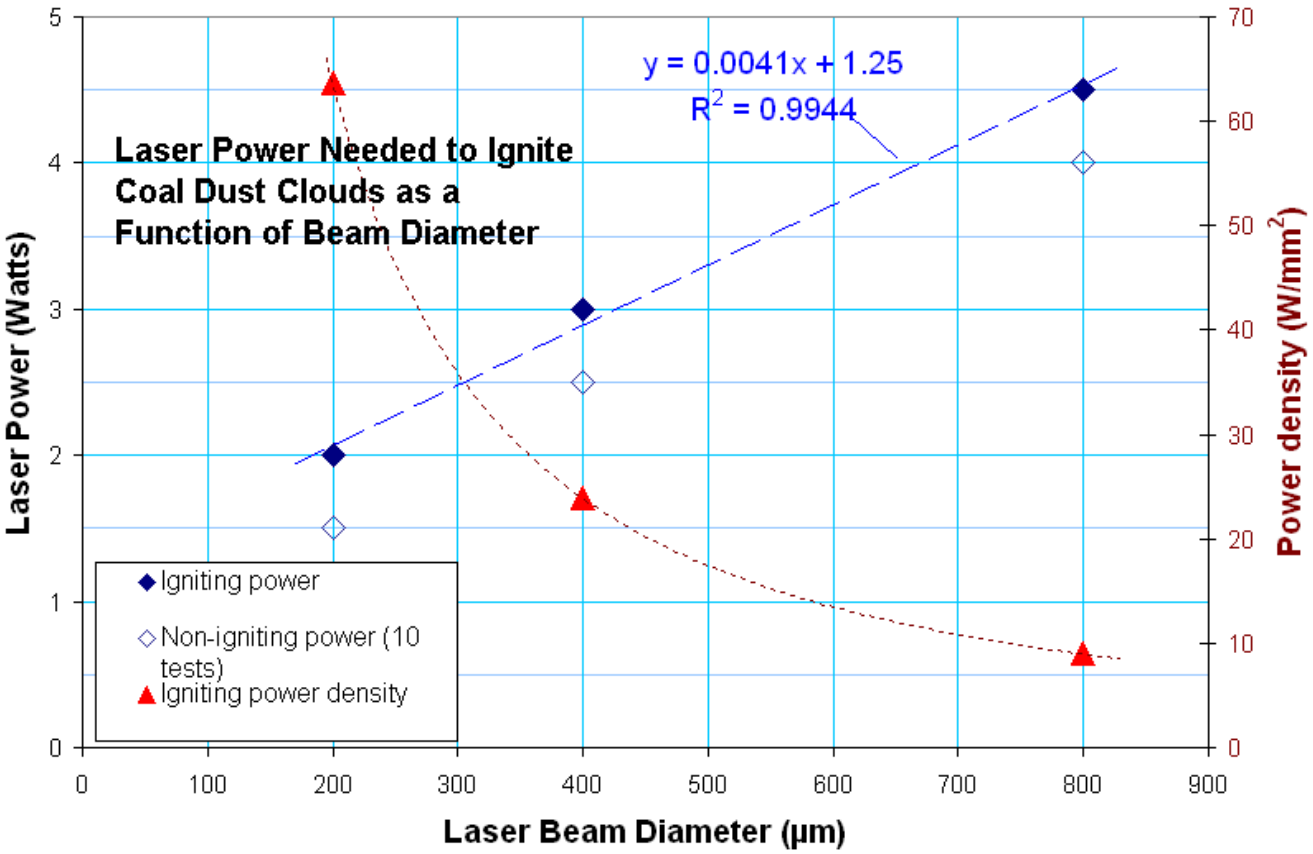
What was discovered?

Laboratories from several countries took part in studying methane-air ignitions in order to independently verify results. The other participating laboratories are located in Australia, United Kingdom, and Germany. NIOSH also performed additional experiments with explosive coal dust clouds. These experiments confirmed that more power is needed to ignite coal dust clouds than is needed to ignite methane-air. Researchers also observed that the amount of laser power needed to create explosions was proportional to the laser beam diameter for the coal dust clouds, as well as for methane-air. This suggests that explosions could be prevented even for relatively powerful beams by ensuring that the beam diameter is large enough to reduce the beam intensity.

The following graphs show "ignition curves" of laser power versus beam diameters. Explosions can be prevented by ensuring that laser systems operate well below these ignition curves.



Laser power needed to ignite methane air as a function of beam diameter.



Laser power needed to ignite coal dust clouds as a function of beam diameter.